THE
QUARTERLY JOURNAL
OF
THE GEOLOGICAL SOCIETY OF LONDON.

VOL. LIX.

---

1. *The* FOSSIL FLORA *of the* CUMBERLAND COALFIELD, *and the* PALÆOBOTANICAL EVIDENCE *with regard to the* AGE *of the* BEDS.

By E. A. NEWELL ARBER, Esq., M.A., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany. (Read November 5th, 1902.)

[PLATES I & II.]

CONTENTS.

Page
- I. Introduction 1
- II. The Fossil Flora of the Cumberland Coalfield 3
  - A. The Sandstone Series 3
    - (1) Localities and Horizons of Plant-Remains.
    - (2) The Flora of the Lower Division of the Sandstone Series.
  - B. The Productive Measures 10
    - (1) Localities and Horizons of Plant-Remains.
    - (2) The Flora of the Upper Division of the Productive Measures.
- III. The Palæobotanical Evidence as to the Age of the Beds in the Whitehaven-Maryport District of the Cumberland Coalfield 15
  - A. The Sandstone Series 15
    - (1) Upper Division.
    - (2) Lower Division.
  - B. The Productive Measures 19
    - (1) Upper Division.
    - (2) Lower Division.
- IV. Conclusions 20
- V. Bibliography 21

I. INTRODUCTION.

THE most important area of the Cumberland Coalfield is situated on, or near, the western coast-line, extending from the neighbourhood of Whitehaven on the south to that of Maryport on the north. The geology of this district was first studied by Sedgwick, and has since formed the subject of numerous memoirs, to many of which reference will here be made. In this paper, however, we are only concerned with the physical and stratigraphical geology of the Cumberland Coalfield, in regard to the horizons from which plant-remains have been obtained, and the evidence which these plants present as to the age of the different beds.

The succession of Upper Carboniferous rocks in the region in question is apparently twofold: an essentially arenaceous series, overlying argillaceous and carbonaceous deposits.[1]

The arenaceous series, of at present unknown vertical extent, but which is at least 600 feet thick, consists of yellowish-grey, red, or purple, massive sandstones, alternating with beds of shale and fireclay of secondary importance. Thin bands of coal and hæmatite also often occur. This series is typically developed in the immediate neighbourhood of Whitehaven, as well as in other parts of the district, and is commonly known as the Whitehaven Sandstone. The term 'Whitehaven Sandstone' has, however, been applied, on grounds which are not entirely satisfactory, to rocks of somewhat similar lithological composition in other districts. I propose, therefore, to speak of this series, as developed in this area of the Cumberland Coalfield, as the Sandstone Series.

The carbonaceous deposits, lying below the Sandstone Series, are at least 1300 feet thick,[2] but here again there is some doubt as to the vertical extent of the series, since the base has not so far been definitely determined.[3] It consists essentially of argillaceous material, containing many seams of coal, often of considerable thickness. These form the productive portion of the Cumberland Coalfield, and are extensively worked in the district in question. Some arenaceous deposits also occur in this series, especially in the lower portions, where this type of rock seems to increase in importance in several localities. The whole of these beds below the Sandstone Series are locally known as the Coal-Measures, or Lower Coal-Measures, but I prefer to speak of them for the present as the Productive Measures, in order to avoid any imputation as to age or horizon; questions which, so far, have not been established on a satisfactory or definite basis.

By almost every observer, from Sedgwick onward, the Sandstone Series has been stated to overlie the Productive Measures unconformably, and this is maintained nowadays by those who are engaged in working the Productive Measures in this district.[4]

---

[1] J. D. Kendall (96) p. 205, etc.; also *id.* (83) p. 321. The numerals in parentheses after the authors' names indicate the year of publication of the paper, to which reference will be found in the Bibliography on p. 21.

[2] J. D. Kendall (83) pp. 347–48 & (96) p. 212.

[3] See p. 20.

[4] Special reference to the unconformity will be found in Sedgwick (32) p. 344, Holmes (96) p. 406, & Kendall (96). So far as I am aware this has only been disputed by Mr. Strahan, on the ground that there was no definite base to the Sandstone Series; see J. D. Kendall (95) Discussion, p. 236, and *id.* (96) p. 205. Personally, I have had no opportunity of studying the junction of the Sandstone Series and Productive Measures in the field, and can therefore offer no observations on this point.

II. The Fossil Flora of the Cumberland Coalfield.

A. The Sandstone Series.

The Sandstone Series may be typically studied in the sea-cliffs immediately north and south of Whitehaven. The series has there been largely denuded, and the uppermost beds are not present.

The upper portion of the Sandstone Series was recognized in 1891 by the late Mr. Brockbank,[1] in a section at Frizington Hall, some 3 miles to the east of Whitehaven. The upper beds were there found to contain bands of *Spirorbis*-Limestone, and were overlain by 20 feet of Permian Brockram. Further reference will be made to this important section, in considering the evidence as to the age of the Sandstone Series.

The Sandstone Series is also overlain by Permian rocks at the Croft Pit of the Whitehaven Colliery Company, 1½ or 2 miles south of Whitehaven, and possibly in other localities. There are few exposures, if any, of these beds at the present time, and only one fossil plant[2] has, so far as I can ascertain, been collected from the Upper Division of the Sandstone Series.

The sandstone forming the cliffs along the coast to the north and south of Whitehaven belongs,[3] as will be shown here, to the Lower Division of the Sandstone Series, and may be spoken of as such. Sections of the coast-line were given by Sedgwick[4] in 1836, and by Dunn[5] in 1860. To the north of Whitehaven that portion of Bransty Cliff, which extends from the William Pit to the Countess or Lamb-Hill Pit,[6] consists of yellowish-grey, or whitish freestones, with alternations of shale and other argillaceous rocks, and thin bands of hæmatite and coal. The beds dip south-westward. The cliff probably averages considerably more than 100 feet in height, and at the William Pit, Whitehaven, the Sandstone Series is believed to extend to 120 feet below sea-level. The total thickness of the Sandstone Series here may be taken as at least 200 feet, if not more.

(1) Localities and Horizons of Plant-Remains.

A considerable number of plant-remains were collected from the Lower Sandstone Series of Bransty Cliff. The friable arenaceous shales, alternating with the massive freestones, are full of plant-impressions. The average height of the different shale-bands, from which the specimens were collected, may be taken as 50 to 80 feet above the base of the Sandstone Series. The sandstone itself, especially near the Countess Pit, contains many fragments of plants, some of which are sufficiently well preserved to admit of identification. The bands of impure fireclay also contain plant-remains.

---

[1] W. Brockbank (91) p. 422.

[2] This is a single pinnule of a fern-like plant, *Neuropteris*, in the possession of Mr. J. D. Kendall, F.G.S.; and was obtained by him at Millyeat. I am indebted to Mr. Kendall for an opportunity of seeing this specimen, and for much information on the Whitehaven district.

[3] W. Brockbank (91) p. 420.

[4] A. Sedgwick (36) pl. xxv, fig. 1.

[5] M. Dunn (60).

[6] This is the first pit along the shore, north of the William Pit, and rather more than half a mile from it.

Besides the plants which I have collected in this locality, there are two other collections in the Woodwardian Museum at Cambridge, one of which is without doubt derived from the Sandstone Series.

The earliest reference to fossil plants from the Upper Carboniferous rocks of Whitehaven is that by John Woodward in his 'Catalogue of English Fossils,' published in 1729. Woodward[1] there mentions, or describes, twenty-four plant-remains from

> 'a dark grey slatey Stone ... at the depth of about 25 Fathom, in Bransty-Cliff, by the Duke of Somerset's Salt-Pans, near Whitehaven.'

These specimens are preserved with the rest of Woodward's historic collections in the Museum which bears his name, at Cambridge. The following is a list of the species from Whitehaven :—

Calamites (Eucalamites) ramosus, Art.
Calamocladus equisetiformis (Schl.).
Neuropteris Scheuchzeri, Hoffm.
Neuropteris obliqua (Brongt.).
Mariopteris (Diplothmema) muricata (Schl.).

The exact locality, and consequently the horizon of Woodward's plants, cannot, despite his full record, be definitely ascertained now.[2] While there seems to me to be very little doubt that these specimens were obtained from the Sandstone Series, I have excluded this collection from the evidence as to the age of the beds in this district, on account of the uncertainty as to the series and horizon from which they were obtained. The opportunity has, however, been taken to figure two of them, *Neuropteris Scheuchzeri* and *N. obliqua* (Pl. I, figs. 1 & 2).

Among the large collection of Palæozoic plant-remains in the Woodwardian Museum, there are several specimens from the Sandstone Series at Whitehaven. These were collected by Sedgwick during his study of this district, and are mentioned by him in his memoirs on the Cumberland Coalfield, read before the Geological Society more than sixty years ago. In 1831[3] he stated that

> 'traces of vegetable fossils occur in this deposit, on the coast of Cumberland, near Whitehaven.'

Ten years later[4] he further stated that

> 'the flora of the Coalfield existed apparently in full perfection during the period of the Lower ... Red Sandstone,'

and that he had obtained many new specimens of this flora. Sedgwick obtained his specimens on the coast at Whitehaven itself. Speaking of the Sandstone Series in 1832, he says :—

> 'It is generally without any trace of fossils : the very extensive excavations carried on in it on both sides of Whitehaven, have, however, brought to light a few obscure impressions of *Equiseta* and *Calamites*.'[5]

---

[1] J. Woodward (1729) pt. ii, p. 16.

[2] At a distance of less than a mile along Bransty Cliff from Whitehaven, the Productive Measures are faulted up against the Sandstone Series.

[3] A. Sedgwick (35) p. 58, footnote.

[4] *Id.* (42) p. 545.

[5] *Id.* (36) p. 395.

The remaining locality from which plant-remains were collected by me is the coal of the Senhouse High Band, at the Ellenborough Colliery, south of Maryport. This seam of coal, which is here of workable thickness, contains numerous impressions of *Sigillaria* and *Stigmaria*. It belongs to the Sandstone Series.[1]

No other plants from the Sandstone Series are apparently to be found in any museum or private collection, apart from those above mentioned in the Woodwardian Museum. I have made many enquiries for specimens in the museums in the North of England, and in London, and also of nearly all those who from time to time have studied the Carboniferous rocks in this district. Several geologists[2] were aware that such plant-remains had been found, but were unable to give particulars of the whereabouts of any specimens.

(2) The Flora of the Lower Division of the Sandstone Series.[3]

Equisetales.

CALAMITES, Suckow, 1784.

Acta Acad. Theod. Palat. vol. v, p. 355.

1. CALAMITES (CALAMITINA) APPROXIMATUS, Brongt. (Pl. I, fig. 3.)

Woodwardian Mus. Camb., Carboniferous Plant Coll. Nos. 416–18, 420, 851, etc. (Sedgwick Collection.)
Locality.—The coast at Whitehaven.

Calamites approximatus.
1828. Brongniart, 'Hist. des Végét. foss.' pl. xxiv, figs. 2–5.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 33.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 191, fig. 187.
Calamitina approximata.
1892. Kidston, Trans. Roy. Soc. Edinb. vol. xxxvii, pt. ii, p. 311 & pl. ii, figs. 5–6.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxxv, fig. 2.
Calamites (Calamitina) approximatus, Brongt.
1884. Weiss, Abhandl. Geol. Specialk. Preussen, vol. v, pt. ii, p. 81 & pl. xxv, fig. 1.
1898. Seward, 'Fossil Plants' vol. i, pp. 369–70 & fig. 100.

Calamitean pith-casts are very common fossils in the Sandstone Series of Whitehaven, and among the specimens in Sedgwick's Collection some are exceedingly well preserved. The cast of *C. approximatus*, part of which is figured on Pl. I, fig. 3, is 4 inches long, and 2½ inches across. There are eight small internodes, each about a quarter of an inch long, succeeded by a larger internode, ⅝ inch in length. The latter bears a row of branch-scars, some of which are seen distinctly in the photograph. Other specimens show twelve small internodes, of approximately equal length, between the larger internodes bearing the branch-scars.

---

[1] J. D. Kendall (83) p. 344 & (96) p. 212.

[2] *Id.* (79) p. 115 & (96) p. 204.

[3] The full synonymy, previous to 1886, will be found in most cases in Kidston's Catalogue of Palæozoic Plants in the British Museum. Only the more recent references, and some of the best-known works in which the species are figured, are mentioned here.

2. CALAMITES (CALAMITINA) VARIANS, Sternb.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 852–53. (Sedgwick Collection.)
Locality.—The coast at Whitehaven.

Calamites approximatus.
1828. Brongniart, 'Hist. des Végét. foss.' pl. xv, figs. 7 & 8, & pl. xxiv, fig. 1.
Calamites varians.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 31.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 197, fig. 193.
Calamites (Calamitina) varians, Sternb.
1884. Weiss, Abhandl. Geol. Specialk. Preussen, vol. v, pt. ii, p. 63, pl. xxv, fig. 2, pl. xxvii, fig. 2, & pl. xxviii, figs. 1–2 & 4.

3. CALAMITES (STYLOCALAMITES) SUCKOWI, Brongt.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 891–93.
Locality.—Bransty Cliff, Whitehaven.

Calamites Suckowi.
1828. Brongniart, 'Hist. des Végét. foss.' p. 124, pl. xiv, fig. 6, pl. xv, figs. 1–6, & pl. xvi, figs. 2–4.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 24.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 333, pl. liv, figs. 2–3 & pl. lv, fig. 1.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 195, figs. 188 (1) & 189.
1900. Zeiller, 'Élém. de Paléobot.' p. 151 & fig. 106 [on p. 149].
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxx, fig. 1 & pl. xxxv, fig. 3.
Calamites (Stylocalamites) Suckowi, Brongt.
1884. Weiss, Abhandl. Geol. Specialk. Preussen, vol. v, pt. ii, p. 129, pl. ii, fig. 1, pl. iii, figs. 2–3, pl. iv, fig. 1, pl. xvii, fig. 4, & pl. xxvii, fig. 3.
1898. Seward, 'Fossil Plants' vol. i, p. 374 & fig. 82 [on p. 323].

4. CALAMITES (STYLOCALAMITES) CISTI, Brongt.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 894–96, & ? 856 & 858. (Sedgwick Coll. in part.)
Locality.—Bransty Cliff, Whitehaven.

Calamites Cisti.
1828. Brongniart, 'Hist. des Végét. foss.' pl. xx.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 30.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 342 & pl. lvi, figs. 1–2.

CALAMOCLADUS, Schimper, 1869.

'Traité Pal. végét.' vol. i, p. 323.

CALAMOCLADUS EQUISETIFORMIS (Schl.).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 898–99.
Locality.—Bransty Cliff, Whitehaven.

Hippurites longifolia.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. iii, pls. cxc & cxci.
Calamocladus equisetiformis.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 38.
1898. Seward, 'Fossil Plants' vol. i, p. 335, fig. 87.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxx, fig. 3.
Asterophyllites equisetiformis.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 368 & pl. lviii, figs. 1–7.
1900. Zeiller, 'Élém. de Paléobot.' p. 161, fig. 113.

ANNULARIA, Sternberg, 1820.

'Versuch einer geogn.-botan. Darstell. d. Flora d. Vorwelt' pt. i, fasc. ii, p. 32.

ANNULARIA SPHENOPHYLLOIDES (Zenker).

Woodwardian Mus. Camb., Carb. Plant Coll. No. 932.
Locality.—Bransty Cliff, Whitehaven.

Annularia sphenophylloides.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 44.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 388 & pl. lx, figs. 5–6.
1898. Seward, 'Fossil Plants' vol. i, p. 341, fig. 89.
1900. Zeiller, 'Élém. de Paléobot.' p. 163, fig. 114.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxxvii, fig. 1.
Annularia brevifolia.
1900. Scott, 'Studies in Fossil Botany' p. 69, fig. 31.

Sphenophyllales.

SPHENOPHYLLUM, Brongniart, 1828.

'Prodr. Hist. des Végét. foss.' p. 68.

SPHENOPHYLLUM CUNEIFOLIUM (Sternb.).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 928–29.
Locality.—Bransty Cliff, Whitehaven.

Sphenophyllum cuneifolium.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 48.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 413, pl. lxii, fig. 1 & pl. lxiii, figs. 1–10.
1893. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 11, vol. iv, p. 12, pl. i, figs. 1–4, pl. ii, figs. 1–3, & pl. iii, figs. 1–2.
1898. Seward, 'Fossil Plants' vol. i, p. 402.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 56 & pl. vi, figs. 6–7.
1900. Zeiller, 'Élém. de Paléobot.' p. 139, fig. 100.
1901. Kidston, Trans. Nat. Hist. Soc. Glasgow, n. s. vol. vi, p. 124, fig. 21 (*a* & *b*).
Sphenophyllum erosum.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. i, pl. xiii.

Lycopodiales.

LEPIDODENDRON, Sternberg, 1820.

'Versuch einer geogn.-botan. Darstell. d. Flora d. Vorwelt,' pt. i, fasc. i, p. 23.

LEPIDODENDRON ACULEATUM, Sternb. (Pl. I, fig. 4.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 47, 48, etc. (Sedgwick Coll.)
Locality.—The coast at Whitehaven.

Lepidodendron aculeatum.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 153.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 435 & pl. lxv, figs. 1–7.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 220, fig. 211.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 72 & pl. vi, fig. 9.
1900. Zeiller, 'Élém. de Paléobot.' p. 180, fig. 123.
1901. Kidston, Trans. Nat. Hist. Soc. Glasgow, n. s. vol. vi, p. 44, figs. 3–4.

The majority of the specimens in Sedgwick's Collection are the remains of *Lepidodendra*. Most of them are more or less decorticated. Some of the least decorticated probably belong to *Lepidodendron aculeatum,* while others, perhaps, belong to species that cannot be definitely identified. Fortunately there are one or two well-preserved examples of the former, of which one is figured in Pl. I, fig. 4. The whole specimen measures 8 by 6 inches. The leaf-bases average $1\frac{1}{2}$ inches in length, and $\frac{5}{8}$ inch across at the widest part. The prints of the bundle, and of the parichnos of the leaf-scar, are well preserved in some of these leaf-bases.

LEPIDOPHLOIOS, Sternberg, 1820.

'Versuch einer geogn.-botan. Darstell. d. Flora d. Vorwelt,' pt. i, fasc. iv, p. 13.

LEPIDOPHLOIOS (HALONIA) sp.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 43 & 189. (Sedgwick Coll.)
Locality.—The coast at Whitehaven.

Cf. *Halonia regularis.*
1831–37. Lindley & Hutton, 'Foss. Flora' vol. iii, pl. ccxxviii.
1872. Binney, Monogr. Palæont. Soc. 'Obs. Struct. Foss. Plants' pt. iii, p. 94 & pl. xviii.

LEPIDOPHYLLUM, Brongniart, 1828.

'Prodr. Hist. des Végét. foss.' p. 87.

LEPIDOPHYLLUM sp.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 930 & 946.
Locality.—Bransty Cliff, Whitehaven.

SIGILLARIA, Brongniart, 1822.

'Sur la Classif. des Végét. foss.' Mém. Mus. Hist. Nat. vol. viii, p. 209.

1. SIGILLARIA SCUTELLATA, Brongt. (Pl. I, fig. 5.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 860. (Sedgwick Coll.)
Locality.—The coast at Whitehaven.

Sigillaria scutellata.
1828. Brongniart, 'Hist. des Végét. foss.' p. 455, pl. cl, figs. 2–3 & pl. clxiii, fig. 3.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 533, pl. lxxxii, figs. 1–6 & 9.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 77 & pl. vi, fig. 18.
1900. Zeiller, 'Élém. de Paléobot.' p. 191, fig. 133.

The only *Sigillaria* among Sedgwick's Whitehaven plants is fortunately a well-preserved specimen, which is figured in Pl. I, fig. 5. Five ribs are shown with three to five leaf-scars on each, which are distant $\frac{5}{8}$ inch one from the other. The folds below the scars, which form one of the characteristics of this species, are also clearly indicated. The specimen measures 4 × 2 inches.

2. SIGILLARIA OVATA, Sauveur.

Woodwardian Mus. Camb., Carb. Plant Coll. No. 901.
Locality.—Senhouse High Band, Ellenborough Colliery, Ellenborough.

Sigillaria ovata.
1848. Sauveur, 'Végét. foss. Terr. houill. de la Belgique' pl. li, fig. 2.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 522 & pl. lxxix, figs. 4–7.
Sigillaria Essenia.
1880–84. Achepohl, 'Niederrh.-Westfal. Steinkohlengeb.' p. 118 & pl. xxxvi, fig. 9.

3. SIGILLARIA LÆVIGATA, Brongt.

Woodwardian Mus. Camb., Carb. Plant Coll. No. 901.
Locality.—Senhouse High Band, Ellenborough Colliery, Ellenborough.

Sigillaria lævigata.
1828. Brongniart, 'Hist. des Végét. foss.' p. 471 & pl. cxliii.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 192.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 519 & pl. lxxviii, figs. 1–4.
1887. Kidston, Trans. Roy. Soc. Edinb. vol. xxxiii, pt. ii, p. 398 & pl. xxviii, fig. 5.

STIGMARIA, Brongniart, 1822.

'Sur la Classif. des Végét. foss.' Mém. Mus. Hist. Nat. vol. viii, p. 209.

STIGMARIA FICOIDES (Sternb.).

Woodwardian Mus. Camb., Carb. Plant Coll. No. 900.
Locality.—Senhouse High Band, Ellenborough Colliery, Ellenborough.

Stigmaria ficoides.
1831–37. Lindley & Hutton, 'Fossil Flora' vol. i, pls. xxxi–xxxvi & vol. iii, pl. clxvi.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 201.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 611 & pl. xci, figs. 1–6.
1887. Williamson, Palæont. Soc. 'Monogr. on *Stigmaria ficoides*' pls. i–xv.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 209, figs. 202–203.
1900. Zeiller, 'Élém. de Paléobot.' p. 200, fig. 139.
1901. Kidston, Trans. Nat. Hist. Soc. Glasgow, n. s. vol. vi, p. 66, fig. 11.

Filicales.

SPHENOPTERIS, Brongniart, 1822.

'Sur la Classif. des Végét. foss.' Mém. Mus. Hist. Nat. vol. viii, p. 233.

SPHENOPTERIS OBTUSILOBA, Brongt.

Woodwardian Mus. Camb., Carb. Plant Coll. No. 931.
Locality.—Bransty Cliff, Whitehaven.

Sphenopteris obtusiloba.
1828. Brongniart, 'Hist. des Végét. foss.' p. 204 & pl. liii, fig. 2*.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 68.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 65, pl. iii, figs. 1–4, pl. iv, fig. 1, & pl. v, figs. 1–2.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 137, fig. 131.
1900. Zeiller, 'Élém. de Paléobot.' p. 82, fig. 51.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxv, fig. 1.

NEUROPTERIS, Brongniart, 1822.

'Sur la Classif. des Végét. foss.' Mém. Mus. Hist. Nat. vol. viii, p. 233.

1. NEUROPTERIS TENUIFOLIA (Schl.).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 933, 935–36, & 939–41.
Locality.—Bransty Cliff, Whitehaven.

Filicites tenuifolius.
1820–23. Schlotheim, 'Petrefactenk.' p. 405 & pl. xxii, fig. 1.
Neuropteris tenuifolia.
1828. Brongniart, 'Hist. des Végét. foss.' p. 241 & pl. lxxii, fig. 3.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 273 & pl. xlvi, fig. 1.

This species is very common in the shaly bands of the lower portion of the Sandstone Series.

2. NEUROPTERIS SCHEUCHZERI, Hoffm. (Pl. I, fig. 1.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 934.
Locality.—Bransty Cliff, Whitehaven.

Neuropteris Scheuchzeri.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 95.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 251 & pl. xli, figs. 1–3.
1887. Kidston, Trans. Roy. Soc. Edinb. vol. xxxiii, pt. ii, p. 356 & pl. xxiii, figs. 1–2.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 43 & pl. iv, fig. 9.

The specimen figured is from the Woodward Collection. It shows a perfect, detached pinnule of a frond. The same species was also found by me in the above locality.

ALETHOPTERIS, Sternberg, 1820.

'Versuch einer geogn.-botan. Darstell. d. Flora d. Vorwelt' pt. i, fasc. iv, p. xxi.

ALETHOPTERIS SERLI (Brongt.).

Woodwardian Mus. Camb., Carb. Plant Coll. No. 937.
Locality.—Bransty Cliff, Whitehaven.

Pecopteris Serli.
1828. Brongniart, 'Hist. des Végét. foss.' p. 292 & pl. lxxxv.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. iii, pl. ccii.
Alethopteris Serli.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 135.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 234, pl. xxxvi, figs. 1–2 & pl. xxxvii, figs. 1–2.
1900. Zeiller, 'Élém. de Paléobot.' p. 95, fig. 68.

Cordaitales.

CORDAITES, Unger, 1850.

'Genera & Species Plantarum fossilium' p. 277.

1. CORDAITES PRINCIPALIS (Germar).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 942–45.
Locality.—Bransty Cliff, Whitehaven.

Cordaites principalis.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 207.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 629, pl. xciii, fig. 3 & pl. xciv, fig. 1.

2. CORDAITES sp.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 725–28. (Sedgwick Coll.)
Locality.—The coast at Whitehaven.

Sternbergia approximata.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. iii, pls. ccxxiv & ccxxv.
Sternbergia.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 221.
Artisia approximata.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 634 & pl. xciv, figs. 2–3.
[*Dadoxylon approximatum.*]
1851. Williamson, Mem. Lit. & Phil. Soc. Manch. ser. 2, vol. ix, p. 340 & figs. 1–11.
Cordaites.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' pp. 266–67, fig. 253.

B. The Productive Measures.

The Productive Measures contain three great coal-seams, which form the most important horizons in the Cumberland Coalfield from the economic standpoint. They are, for the most part, of constant thickness, and are easily traced throughout the district, although known locally under different names.[1] The thickest seam is known at Whitehaven as the 'Main Band,' and is there 10 feet thick. At the William Pit, Whitehaven, it lies 455 feet below the base of the Sandstone Series, and 576 feet from the surface. In the northern portion of the area, in the neighbourhood of Maryport, this seam is split into an upper, or 'Metal Band,' and a lower, the 'Cannel Band.' The 'Bannock Band,' another important seam, lies about 135 feet above the Main Band at Whitehaven, and is there 7 to 8 feet thick. The 'Six Quarters Coal' at Whitehaven is about 255 feet below the Main Band, and 7½ feet thick.

---

[1] J. D. Kendall (83) p. 340.

(1) Localities and Horizons of Plant-Remains.

Fossil plants do not appear to be so abundant in the Cumberland Coalfield as in some other coalfields. The finest plants collected were from the Cannel Band in the Robin Hood Pit at Flimby, south of Maryport, belonging to the Flimby & Broughton-Moor Coal Company. I am indebted to Mr. Lloyd Wilson, of the above Company, for special facilities for obtaining this collection. The plants occur there in the shales forming the roof of the Cannel Coal, from 3 inches to 2 feet above the seam. This band is believed to lie about 380 feet below the Sandstone Series.[1]

I also obtained plants from the shales above the Main Band at Walk Mill Pit, Moresby, rather more than 2 miles east of Whitehaven. A few specimens, from the same horizon in the William Pit at Whitehaven, were forwarded to me by the kindness of the manager, Mr. Turner.

All the plants from the Productive Series are thus from the horizon of the Main Band, which, as will be shown, belongs to the Upper Division of the Productive Measures. Attempts have been made to obtain specimens from the Bannock Band, and especially from seams below the Main Band, but without success.

So far as I am aware, with the exception of a few specimens at Keswick and Oxford, mostly without record of horizons, no collection from the Productive Measures of Cumberland is to be found in any museum. The only specimens that have been described and figured from the Whitehaven Coalfield are Lindley & Hutton's *Sphenopteris crenata* and *Schizopteris adnascens*[2]; the types of these are in the Museum of the Northumberland & Durham Natural History Society at Newcastle-on-Tyne. Mr. Kidston has shown that both Lindley & Hutton's species belong to *Pecopteris (Dactylotheca) plumosa*, Art.[3]

(2) The Flora of the Upper Division of the Productive Measures.

Equisetales.

CALAMITES.

1. CALAMITES (CALAMITINA) VARIANS, Sternb. (See p. 6.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 911.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

---

[1] From information supplied by the above-mentioned Company.

[2] J. Lindley & W. Hutton (31) vol. ii, pls. c & ci. I am indebted to Mr. Kidston for calling my attention to this fact.

[3] R. Kidston (94) p. 245.

2. Calamites (Stylocalamites) Suckowi, Brongt. (See p. 6.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 911 & 905.
Localities.—Above the Cannel Band, Robin Hood Pit, Flimby; above the Main Band, Walk Mill Pit, Moresby.

3. Calamites (Stylocalamites) Cisti, Brongt.? (See p. 6.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 906 & 960.
Localities.—Above the Main Band, Walk Mill Pit, Moresby; above the Main Band, William Pit, Whitehaven.

CALAMOCLADUS.

Calamocladus equisetiformis (Schl.). (See p. 6.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 906 & 908.
Locality.—Above the Main Band, Walk Mill Pit, Moresby.

Pinnularia, Lindley & Hutton, 1833–35.

'Fossil Flora' vol. ii, p. 81.

Pinnularia sp.

Woodwardian Mus. Camb., Carb. Plant Coll. No. 924.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Sphenophyllales.

SPHENOPHYLLUM.

Sphenophyllum cuneifolium (Sternb.) (See p. 7.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 913, 914, & 918.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Lycopodiales.

LEPIDODENDRON.

1. Lepidodendron Wortheni, Lesq. (Pl. II, fig. 6.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 926, 949, & 951.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Lepidodendron Wortheni.
1866. Lesquereux, 'Geol. Surv. Illinois' vol. ii, p. 452 & pl. xliv, figs. 4–5.
1880. Lesquereux, 'Coal-Flora of the Carbon. in Pennsylvania, &c.' 2nd Geol. Surv. Penn. Report of Progr. P, vol. ii, p. 388 & pl. lxiv, figs. 8–9.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 467 & pl. lxxi, figs. 1–3.
1901. Kidston, Trans. Nat. Hist. Soc. Glasgow, n. s. vol. vi, p. 46, fig. 6.

2. Lepidodendron lycopodioides, Sternb. (Pl. II, fig. 5.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 927 & 950–51.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Lepidodendron elegans.
1837. Brongniart, 'Hist. des Végét. foss.' vol. ii, p. 35 & pl. xiv.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. ii, pl. cxviii.
Lepidodendron lycopodioides.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 464, pl. lxix, figs. 2–3 & pl. lxx, fig. 1.
1893. Kidston, Geol. Trans. Yorks. Nat. Union, 'The Yorkshire Carboniferous Flora' 4th Rep. p. 109.

SIGILLARIA.

SIGILLARIA LÆVIGATA, Brongt. (See p. 8.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 912.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

BOTHRODENDRON, Lindley & Hutton, 1833.

'Fossil Flora' vol. ii, p. 1.

BOTHRODENDRON MINUTIFOLIUM (Boulay)?

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 917 & 919.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Rhytidodendron minutifolium.
1876. Boulay, 'Terr. houill. du Nord de la France' p. 39, pl. iii, figs. 1 & 1 bis.
Bothrodendron minutifolium.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 491 & pl. lxxiv, figs. 2–4.
1889. Kidston, Ann. & Mag. Nat. Hist. ser. 6, vol. iv, p. 64, pl. iv & figs. 5–6.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 242, fig. 227.
1901. Kidston, Trans. Nat. Hist. Soc. Glasgow, n. s. vol. vi, pp. 34 & 85, figs. 14–15.

STIGMARIA.

STIGMARIA FICOIDES (Sternb.). (See p. 9.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 903.
Locality.—Above the Main Band, Walk Mill Pit, Moresby.

Filicales.

ZEILLERIA, Kidston, 1884.

Quart. Journ. Geol. Soc. vol. xl, p. 590.

ZEILLERIA DELICATULA (Sternb.). (Pl. II, figs. 1 & 2.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 920–21.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Zeilleria delicatula.
1884. Kidston, Quart. Journ. Geol. Soc. vol. xl, p. 592 & pl. xxv.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 66.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 103, fig. 90 (iii).

SPHENOPTERIS.

1. SPHENOPTERIS OBTUSILOBA, Brongt. (See p. 9.) (Pl. II, fig. 3 *b*.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 916 & 922.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

2. SPHENOPTERIS FURCATA, Brongt. (Pl. II, fig. 3 *a*.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 916 & 922.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

Sphenopteris furcata.
1828. Brongniart, 'Hist. des Végét. foss.' p. 179 & pl. xlix, figs. 4–5.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. iii, pl. clxxxi.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 80.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, pl. xxvii, fig. 2.

Palmatopteris furcata.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 120, fig. 106.
1900. Zeiller, 'Élém. de Paléobot.' pp. 85–86, fig. 57.
Diplothmema furcatum.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 147, pl. iv, figs. 5–6 & pl. v, fig. 4.

MARIOPTERIS, Zeiller, 1879.

Bull. Soc. géol. France, ser. 3, vol. vii, p. 92.

1. MARIOPTERIS MURICATA (Schl.).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 907, 908, 917, 919 & 921.
Localities.—Above the Cannel Band, Robin Hood Pit, Flimby; above the Main Band, Walk Mill Pit, Moresby.

Mariopteris muricata.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 109.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 173 & pls. xx–xxiii.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 32 & pl. ii, figs. 14–15.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 140, fig. 135.
1900. Zeiller, 'Élém. de Paléobot.' p. 94, fig. 67.
Diplothmema muricatum.
1885. Stur, Abhandl. k.k. Geol. Reichsanst. vol. xi, pt. i, p. 393 & pls. xxi–xxiii.
Pecopteris laciniata.
1831–37. Lindley & Hutton, 'Foss. Flora' vol. ii, pl. cxxii.
Pecopteris muricata.
1828. Brongniart, 'Hist. des Végét. foss.' p. 352, pl. xcv, figs. 3–4 & pl. xcvii.

2. MARIOPTERIS LATIFOLIA (Brongt.).

Woodwardian Mus. Camb., Carb. Plant Coll. No. 904.
Locality.—Above the Main Band, Walk Mill Pit, Moresby.

Mariopteris latifolia.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 112.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 161, pl. xvii, figs. 1–2 & pl. xviii, fig. 1.
Diplothmema latifolium.
1885. Stur, Abhandl. k.k. Geol. Reichsanst. vol. xi, pt. i, p. 361 & pl. xxvi, figs. 1–2.
Sphenopteris latifolia.
1828. Brongniart, 'Hist. des Végét. foss.' p. 205 & pl. lvii, figs. 1–5.

3. MARIOPTERIS sp. (Pl. II, fig. 4.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 917–19.
Locality.—Above the Cannel Band, Robin Hood Pit, Flimby.

These specimens are interesting, as the preservation is unusual. The pinnules have the appearance of being thick, and somewhat reflexed at the edges. The nervation is not at all clear; but I have referred them to this genus on the general habit of the plant.

NEUROPTERIS.

1. NEUROPTERIS HETEROPHYLLA, Brongt.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 955 & 961–63.
Localities.—Above the Main Band, William Pit, Whitehaven; above the Cannel Band, Robin Hood Pit, Flimby.

Neuropteris heterophylla.
1828. Brongniart, 'Hist. des Végét. foss.' p. 243, pl. lxxi & pl. lxxii, fig. 2.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 85.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 261, pl. xliii, figs. 1–2 & pl. xliv, fig. 1.

2. NEUROPTERIS TENUIFOLIA (Schl.). (See p. 9.)

Woodwardian Mus. Camb., Carb. Plant Coll. No. 947.
Locality.—Above the Main Band, Walk Mill Pit, Moresby.

3. NEUROPTERIS GIGANTEA, Sternb.

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 938, 948, & 952.
Locality.—Above the Main Band, Walk Mill Pit, Moresby.

Neuropteris gigantea.
1828. Brongniart, 'Hist. des Végét. foss.' p. 240 & pl. lxix.
1886. Kidston, 'Catal. Palæoz. Plants Brit. Mus.' p. 92.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 258 & pl. xlii, fig. 1.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 151, figs. 101, 105, & 150.
1899. Zeiller, Mém. Soc. géol. France, Paléont. Mém. No. 21, vol. viii, p. 44 & pl. iv, fig. 10.
1900. Zeiller, 'Élém. de Paléobot.' p. 105, fig. 79.
1901. Kidston, Proc. Yorks. Geol. & Polytechn. Soc. n. s. vol. xiv, p. 193, pl. xxviii, fig. 3 & pl. xxix, fig. 4.

ALETHOPTERIS.

ALETHOPTERIS DECURRENS (Art.).

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 902, 915, & 925.
Localities.—Above the Cannel Band, Robin Hood Pit, Flimby; above the Main Band, Walk Mill Pit, Moresby.

Pecopteris Mantelli.
1828. Brongniart, 'Hist. des Végét. foss.' p. 278 & pl. lxxxiii, figs. 3–4.
1831–37. Lindley & Hutton, 'Fossil Flora' vol. ii, pl. cxlv.
Alethopteris decurrens.
1886–88. Zeiller, 'Bassin houill. de Valenciennes' p. 221, pl. xxxiv, figs. 2–3, pl. xxxv, fig. 1, & pl. xxxvi, figs. 3–4.
1899. Potonié, 'Lehrb. d. Pflanzenpal.' p. 146, fig. 141.

Cordaitales.

CORDAITES.

CORDAITES PRINCIPALIS (Germar). (See p. 10.)

Woodwardian Mus. Camb., Carb. Plant Coll. Nos. 906, 909, 910, & 915.
Localities.—Above the Cannel Band, Robin Hood Pit, Flimby; above the Main Band, Walk Mill Pit, Moresby.

III. THE PALÆOBOTANICAL EVIDENCE AS TO THE AGE OF THE BEDS IN THE WHITEHAVEN-MARYPORT DISTRICT OF THE CUMBERLAND COALFIELD.

A. The Sandstone Series.

It is well known that the age of the lower division of the Sandstone Series was for many years regarded as Permian. Sedgwick,[1] who was probably the first to undertake a systematic study of the Cumberland Coalfield, concluded

> 'that in . . . these regions the Lower Red Sandstone represents the *rothe todte liegende*, or lowest division of the red sandstone series.'

Previous to Sedgwick's conclusions, this series had been universally regarded as a member of the true Coal-Measures.[2] Sedgwick's views were maintained as late as 1859 by Matthias Dunn.[3] The late

---

[1] A. Sedgwick (32) p. 345 & (36).
[2] *Id.* (36) p. 395.
[3] M. Dunn (60) p. 141.

E. W. Binney[1] was apparently the first to suspect the correctness of this conclusion, and the rocks in question have been for many years almost universally regarded as Upper Carboniferous in age. As such they appear on the two editions of the Geological Survey Map[2] of the Whitehaven district, published in 1892 and 1895.

The exact horizon of the Sandstone Series in the Carboniferous, as also the position of the Productive Measures, are still disputed questions. The most recently-published theory on the subject is that both these series are probably older than the true Coal-Measures.[3]

Prof. Hull[4] in his 'Coalfields of Great Britain' did not definitely assign the Sandstone Series to any particular horizon in the Coal-Measures.[5] He classified the Upper Carboniferous formations as follows:—

'Coal-measures 2,000 feet.	1. (?) Massive reddish sandstone of Whitehaven. Professor Sedgwick appears doubtful of the affinities of this rock—100 to 150 feet. 2. *Middle*, most fully developed at Cleat Moor, containing 7 workable coal-seams. 3. *The Lower*, with 4 or 5 thin and inferior coal-seams.'

Mr. J. D. Kendall[6] has concluded that the whole of the Sandstone Series is of Upper Coal-Measure age. Mr. T. V. Holmes[7] in 1896 stated that

> 'the only evidence we have about the position among the Coal-Measures of the Whitehaven Sandstone is that furnished by the Frizington-Hall boring.'

It would therefore seem that any fresh light, which a study of the fossil plant-remains may tend to throw on the vexed subject of the age of these beds, would be welcome.

In the first place, the plants obtained from the Sandstone Series confirm, in a most emphatic manner, the conclusions as to the Carboniferous age of the Sandstone Series. The discovery of the *Spirorbis*-Limestone, at a higher horizon in the Sandstone Series than that from which the plants were obtained, renders further proof unnecessary.

The examination of the boring in the Sandstone Series at Frizington Hall by the late Mr. Brockbank[8] in 1891, showed that the Series may probably be divided into two divisions; but the discovery of *Spirorbis*-Limestone did not, as will be shown here, fix the horizon of the Upper Division beyond doubt. As the boring in question must be referred to in some detail, it may be well to give a condensed account of its principal features, taken from the table in Mr. Brockbank's paper.[1]

---

[1] E. W. Binney (55) p. 209.

[2] Geol. Surv. Engl. & Wales, 1-inch map, Quarter-sheet 101 S.W., 1892 & 1895.

[3] J. G. Goodchild (n. d.) pp. 20, 27–30.

[4] [My attention has been called, since the reading of this paper, to a footnote (p. 215) in the 3rd edition of 'The Coalfields of Great Britain,' where Prof. Hull states that 'after a personal inspection of this sandstone, I feel no doubt of its belonging to the Coal-Measures.' The same note, and a classification of formations identical with that in the 3rd edition above-quoted, occurs also in the 4th (latest) edition (1881) p. 227.—E. A. N. A., *Dec. 9th, 1902.*]

[5] E. Hull (73) p. 215.

[6] J. D. Kendall (83) p. 322, (95) p. 235, & (96) p. 204.

[7] T. V. Holmes (96) p. 413.

[8] W. Brockbank (91) p. 424.

	Thickness.		*Depth below surface.*	
	Feet	inches.	Feet	inches.
3. Permian Breccia	20	0	42	0
2. Red and purple sandstones, shales, and conglomerates, with two thin bands of *Spirorbis*-Limestone, and three thin bands of coal	418	8	460	8
1. Red and purple sandstones, shales, and conglomerates	112	7	573	3
Boring ended.				

The occurrence of 20 feet of Permian Breccia, above the *Spirorbis*-Limestone, shows that in all probability the whole of the upper part of the Sandstone Series is present here. Mr. Brockbank was of opinion that, at a depth of roughly 420 feet below the Permian, or 214 feet below the lower band of *Spirorbis*-Limestone, the sandstones presented a similar appearance to those at Whitehaven. If the lower 112 feet is thus correctly identified, then he says[2] 'they thus become Middle Coal-Measure sandstones beyond doubt.' There is no evidence that, even at 573 feet, when the boring ended, the basal beds of the Sandstone Series had been reached. Indeed, if we remember that this series in Bransty Cliff, near Whitehaven, is at least 170 feet thick,[3] and has there been largely denuded, it is probable that the bore only passed through a portion of the full extent of the Lower Division of the Sandstone Series.

(1) Upper Division, Sandstone Series.

The only palæontological evidence, as to the horizon of the Upper Division of the Sandstone Series, is the occurrence of the two bands of *Spirorbis*-Limestone. The value of *Spirorbis*, as marking a particular zone in the Coal-Measures, is, however, becoming smaller every year, in view of the wide vertical range which this fossil has been proved to possess in certain districts. This is particularly the case in the Upper Carboniferous rocks of North Staffordshire, as Mr. Walcot Gibson[4] has recently shown. Mr. Kidston tells me that he has also found that the occurrence of *Spirorbis* does not agree with the evidence of fossil plants in other districts. If, therefore, the occurrence of *Spirorbis* at Frizington Hall can be regarded as of any value at all, it probably points to the Upper Division of the Sandstone Series as belonging to the Transition Coal-Measures, an horizon established by Mr. Kidston[1] as intermediate between the Upper and Middle Coal-Measures, and of which the best-known examples are the Lower Pennant Rocks in the South Wales Coalfield, and the New Rock and Vobster Series in the Somerset Coalfield. Trasition Coal-Measures occur also in the Potteries Coalfield of North Staffordshire.

---

[1] W. Brockbank (91) p. 418.
[2] *Ibid.* p. 420.
[3] J. D. Kendall (96) p. 202.
[4] W. Gibson (01) p. 253.

(2) Lower Division, Sandstone Series.

The fossil flora of the Lower Division of the Sandstone Series is undoubtedly of Middle Coal-Measure age. This confirms the late Mr. Brockbank's conclusions.

LIST OF PLANT-REMAINS FROM THE LOWER DIVISION OF THE 'SANDSTONE SERIES.'

- *Calamites (Calamitina) approximatus*, Brongt.
- *Calamites (Calamitina) varians*, Sternb.
- *Calamites (Stylocalamites) Suckowi*, Brongt.
- *Calamites (Stylocalamites) Cisti*, Brongt.
- *Calamocladus equisetiformis* (Schl.).
- *Annularia sphenophylloides* (Zenker).
- *Sphenophyllum cuneifolium* (Sternb.).
- *Lepidodendron aculeatum*, Sternb.
- *Lepidophloios (Halonia)* sp.
- *Lepidophyllum* sp.
- *Sigillaria scutellata*, Brongt.
- *Sigillaria ovata*, Sauveur.
- *Sigillaria lævigata*, Brongt.
- *Stigmaria ficoides* (Sternb.).
- *Sphenopteris obtusiloba*, Brongt.
- *Neuropteris tenuifolia* (Schl.).
- *Neuropteris Scheuchzeri*, Hoffm.
- *Alethopteris Serli* (Brongt.).
- *Cordaites principalis* (Germ.).
- *Cordaites* sp.

The aggregate or assemblage of fossil-types, and the abundance of certain groups or genera, as shown here, all point to Middle, and not to Upper Coal-Measures, as the age of these beds. The common occurrence of *Calamites* and *Lepidodendra*, in association with *Sigillaria* and *Cordaites*, favours this conclusion.

There is also an entire absence of those types of fern-like plants that are associated essentially with the Upper Coal-Measures. It is true that some of these plants, such as *Calamites approximatus*, *Lepidodendron aculeatum*, and *Sigillaria scutellata*, extend to the Transition, or even to the Upper Coal-Measures, but these species are all much more characteristic of the Middle and Lower Coal-Measures than of the Upper Series.[2] Finally, the occurrence of *Sigillaria ovata*, a plant confined to the Middle Coal-Measures, confirms this conclusion.

In a paper, which is concerned entirely with palæobotanical evidence, it is not possible, at present, to offer any opinion on the disputed question of the correlation of rocks, of somewhat similar petrological structure, in other districts with the Sandstone Series of Cumberland. Mr. Holmes[3] has repeatedly put forward the view that the Red Rock of Rotherham in Yorkshire is the equivalent of the Whitehaven Sandstone. No plants have been described from these Yorkshire beds, so far as I am aware; and I have been unable, after many enquiries, to ascertain the existence of such remains in any museum, with the exception of two specimens in the Woodwardian Museum at Cambridge.[1] Until such specimens have been obtained (and there would seem to be no reason to doubt the existence of a fossil flora), there is no evidence of a palæobotanical character on this point.

---

[1] R. Kidston (94) pp. 228–29, and (97) p. 129. Mr. Kidston tells me that he proposes to speak of this horizon in future as the Upper Transition Coal-Measures.

[2] R. Kidston (94) pp. 228 & 233.

[3] T. V. Holmes (83) p. 409 & (96) p. 407.

B. The Productive Measures.

Sedgwick[2] divided these Measures into an upper portion, including the Main and Bannock Bands, and a lower, represented by four or five workable but inferior coals. The opinions of Prof. Hull and others, as to the horizons represented by these beds, have already been quoted.

(1) Upper Division, Productive Measures.

The following plant-remains were obtained from the horizon of the Main Band in various localities in the Cumberland Coalfield:—

LIST OF PLANT-REMAINS FROM THE UPPER DIVISION OF THE 'PRODUCTIVE MEASURES.'

**Calamites (Calamitina) varians*, Sternb.
**Calamites (Stylocalamites) Suckowi*, Brongt.
**Calamites (Stylocalamites) Cisti*, Brongt. ?
**Calamocladus equisetiformis* (Schl.).
Pinnularia sp.
**Sphenophyllum cuneifolium* (Sternb.).
Lepidodendron Wortheni, Lesq.
Lepidodendron lycopodioides, Sternb.
**Sigillaria lævigata*, Brongt.
Bothrodendron minutifolium (Boulay)?
**Stigmaria ficoides* (Sternb.).
Zeilleria delicatula (Sternb.).
**Sphenopteris obtusiloba*, Brongt.
Sphenopteris furcata, Brongt.
Mariopteris muricata (Schl.).
Mariopteris latifolia (Brongt.).
Mariopteris sp.
Neuropteris heterophylla, Brongt.
**Neuropteris tenuifolia* (Schl.).
Neuropteris gigantea, Sternb.
Alethopteris decurrens (Art.).
**Cordaites principalis* (Germar).

The conclusion drawn from this flora is that the horizon of the Main Band is undoubtedly of Middle Coal-Measure age. The remarks made in regard to the flora of the Lower Division of the Sandstone Series apply equally here; and the occurrence of *Zeilleria delicatula*, a plant confined to the Middle Coal-Measures, places the matter beyond doubt, so far as our present knowledge of the distribution of fossil-plants is concerned. The flora is also largely identical with that above mentioned, nearly half the species being common to the two. In the foregoing list, those species marked with an asterisk (*) are represented in both floras. Finally, the occurrence of such plants as *Lepidodendron Wortheni*, *Sigillaria lævigata*, and *Neuropteris tenuifolia* at once serves to distinguish this from a Lower Coal-Measure flora.

With, I think, only one exception, all the plants mentioned here from the Sandstone Series, and also from the Productive Measures, have been recorded from the Middle Coal-Measures of Yorkshire,[1] and the great majority also from the Middle Coal-Measures of Lancashire.[2]

---

[1] These are a fine specimen of *Sigillaria tessellata* (Schl.) and a leaf of *Alethopteris lonchitica* (Schl.), both recorded from Rotherham, but without horizon.

[2] A. Sedgwick (36) p. 393.

I am happy to be able to state that Mr. Kidston, to whom I have shown the evidence presented here, entirely agrees with me as to the age of both these floras.

(2) Lower Division, Productive Measures.

With regard to the age of horizons in the Productive Measures, below the Main Band, nothing definite is known at present. No fossils of any sort have been described from these beds, and attempts to obtain plant-remains have not been successful. The full extent of the Middle Coal-Measures, as also the existence, or non-existence of Lower Coal-Measures, has yet to be demonstrated.

Among the many geological problems awaiting solution in this district, the identification of the base of the Productive Measures, the Millstone Grit, is one of the most important. After careful enquiries, I find that this rock has never been identified in any section beneath the Main Band at any colliery, or boring, in this district of the Cumberland Coalfield. Yet in the Geological Survey 1-inch Map,[3] rocks, described as Millstone Grit, are shown to crop out some 4 or 5 miles inland from the coast, from Whitehaven to Workington. The base of the Productive Measures is therefore at present undefined. In two localities at least:—at Harrington, and recently in the Ladysmith Shaft of the Croft Pit, Whitehaven, a limestone, presumably to be regarded as Carboniferous Limestone, has been reached below the coals. In the latter case [4] the limestone was first reached at 327 feet below the Main Band, and between these two horizons, arenaceous and argillaceous rocks occurred in nearly equal proportions, and also several coal-seams. The boring ended at a depth of 89 feet beyond the first limestone, passing through sandstones, shales, and several other limestone-bands. The above record may serve as an illustration of the uncertainty, which at present prevails, as to the base and extent of the Productive Measures.

IV. Conclusions.

The chief conclusions, based on the discovery of fossil floras in the Lower Division of the Sandstone Series, and in the Upper Division of the Productive Measures, are that both these divisions are of Middle Coal-Measure age. Consequently the change in lithological conditions, which resulted in the deposition of the Sandstone Series above the Productive Measures, took place in Middle Coal-Measure times. Also, since there was a considerable accumulation of both types of deposit during that period, the unconformity, if present, between the two, does not mark any considerable interval in geological time, during which there was a cessation of deposition, and a period of erosion. The following table summarizes the main conclusions arrived at:—

---

[1] R. Kidston (90).

[2] *Id.* (92).

[3] Quarter-sheet 101 S.W. 1895.

[4] From particulars kindly supplied by Mr. James, Secretary of the Whitehaven Colliery Company.

The Age of the Upper Carboniferous Beds of Cumberland, based on Palæontological Evidence.

System.	*Series.*	*Stage.*	*Thickness in feet.*	*Petrological Character.*	*Palæontological Evidence.*	*Horizon.*
PERMIAN.	Brockram.		20	Red breccia.		Lr. Permian.
UPPER CARBONIFEROUS.	Sandstone Series (Whitehaven Sandstone in part). 600 feet at least.	Upper Division.	418	Red & purple sandstone.	*Spirorbis*-Limestone (Brockbank 1891).	? Transition Coal-Measures.
		Lower Division.	200 at least.	Red or grey sandstone.	Middle Coal-Measure flora.	Middle Coal-Measures.
	Productive Measures. ? 1300 feet.	Upper Division, including Bannock and Main Bands.	450 at least [William Pit, Whitehaven].	Dark-coloured shales and coal.	Middle Coal-Measure flora.	
		(?) Lower Division.	(?)	(?)	—	? Lower Coal-Measures, and Millstone Grit.

In conclusion, I wish to express my great indebtedness to Mr. P. L. Addison, F.G.S., of Bigrigg, for the kindness with which he obtained for me every facility for the collection of specimens in the field, and for special help in many directions. I am also under obligations to Mr. Robert Kidston, F.R.S., who has most kindly given me the benefit of his opinion on special points of identification. I should also like to take this opportunity of expressing my thanks to many Fellows of the Geological Society, who have kindly answered enquiries, and given me information concerning the Cumberland District.

V. BIBLIOGRAPHY.

BINNEY, E. W. (55). 'On the Permian Beds of the North-west of England' Mem. Lit. & Phil. Soc. Manch. ser. 2, vol. xii, p. 209. 1855.

BROCKBANK, W. (91). 'On the Occurence of the Permians, &c. in the Whitehaven District' Mem. & Proc. Lit. & Phil. Soc. Manch. ser. 4, vol. iv, p. 418. 1891.

DUNN, M. (60). 'The Coalfields of Cumberland, &c.' Trans. N. Engl. Inst. Min. & Mech. Eng. vol. viii, p. 141. 1860.

GIBSON, WALCOT (01). 'On the Character of the Upper Coal-Measures of North Staffordshire, &c.' Quart. Journ. Geol. Soc. vol. lvii, p. 251. 1901.

GOODCHILD, J. G. (n. d.). 'The Victoria History of the County of Cumberland vol. i, n. d. (? 1901), Nat. Hist.—Geol. Section, p. 1.

HOLMES, T. V. (83). 'Notes on the Geology of Cumberland, North of the Lake District' Proc. Geol. Assoc. vol. vii, p. 404. 1883.

HOLMES, T. V. (96). 'Notes on the Whitehaven Sandstone' Geol. Mag. n. s. dec. iv, vol. iii, p. 405. 1896.

HULL, E. (73). 'The Coalfields of Great Britain' 3rd ed. London, 1873.

KENDALL, J. D. (79). 'The Hæmatite-Deposits of West Cumberland' Trans. N. Engl. Inst. Min. & Mech. Eng. vol. xxviii, p. 109. 1879.

KENDALL, J. D. (83). 'The Structure of the Cumberland Coalfield' Trans. N. Engl. Inst. Min. & Mech. Eng. vol. xxxii, p. 319. 1883.

KENDALL, J. D. (95). 'The Whitehaven Sandstone Series' Quart. Journ. Geol. Soc. vol. li, p. 235. 1895.

KENDALL, J. D. (96). 'The Whitehaven Sandstone Series' Trans. Fed. Inst. Min. Eng. vol. x, p. 202. 1896.

KIDSTON, R. (90). 'The Yorkshire Carboniferous Flora'—Reports 1–5, Trans. Yorks. Nat. Union. 1890–95.

KIDSTON, R. (92). 'Notes on some Fossil Plants from the Lancashire Coal-Measures' Trans. Manch. Geol. Soc. vol. xxi, p. 401 & vol. xxii, p. 632. 1892 & 1895.

KIDSTON, R. (94). 'On the Various Divisions of British Carboniferous Rocks as determined by their Fossil Flora' Proc. Roy. Phys. Soc. Edinb. vol. xii, p. 183. 1894.

KIDSTON, R. (96). 'On the Fossil Flora of the Yorkshire Coalfield,' First Paper, Trans. Roy. Soc. Edinb. vol. xxxviii, pt. i, p. 203. 1896.

KIDSTON, R. (97) 'Additional Records & Notes on the Fossil Flora of the Potteries Coalfield' Trans. N. Staffs. Field-Club, vol. xxxi, p. 127. 1897.

LINDLEY, J., & HUTTON, W. (31). 'The Fossil Flora of Great Britain' vols. i–iii. 1831–37.

SEDGWICK, A. (32). 'On the Deposits overlying the Carboniferous Series in the Valley of the Eden, &c.' Proc. Geol. Soc. vol. i, p. 343. 1826–33 (1st Feb. 1832).

SEDGWICK, A. (35). 'Introduction to the General Structure of the Cumbrian Mountains, &c.' Trans. Geol. Soc. ser. 2, vol. iv, pt. i, p. 47. 1835.

SEDGWICK, A. (36). 'On the New Red Sandstone Series in the Basin of the Eden, &c.' Trans. Geol. Soc. ser. 2, vol. iv, pt. ii, p. 383. 1836.

SEDGWICK, A. (42). 'Supplement to a "Synopsis of the English Series of Stratified Rocks inferior to the Old Red Sandstone," &c.' Proc. Geol. Soc. vol. iii, pt. ii, p. 545. 1842.

WOODWARD, J. (1729). 'An Attempt towards a Natural History of the Fossils of England in a Catalogue of the English Fossils in the Collection of J. Woodward, M.D.' pts. i & ii, London, 8vo. 1729.

EXPLANATION OF PLATES I & II.

All the specimens are in the Woodwardian Museum, Cambridge.

[The figures are reproduced from photographs taken by Mr. Tams, Cambridge. They are all approximately of the natural size, except Pl. II, fig. 2.]

PLATE I.

Fossil Plants from the Sandstone Series.

Figs. 1 & 2 from specimens in the John Woodward collection, formed before 1729 A.D.; figs. 3–5 from specimens collected by Adam Sedgwick.

Fig. 1. *Neuropteris Scheuchzeri*, Hoffm.
2. *Neuropteris obliqua* (Brongt.).
3. *Calamites* (*Calamitina*) *approximatus*, Brongt.
4. *Lepidodendron aculeatum*, Sternb.
5. *Sigillaria scutellata*, Brongt.

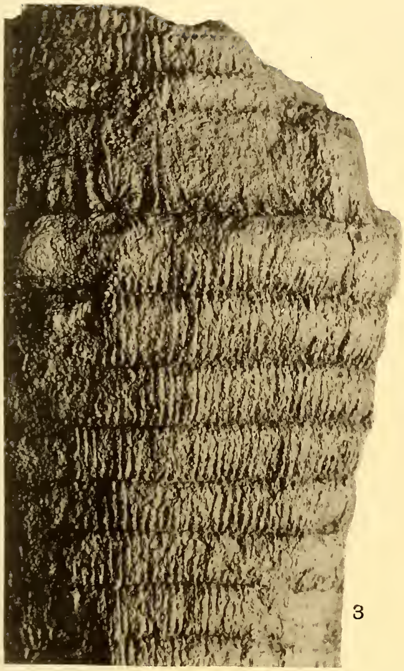
PLATE II.

Fossil Plants from the Productive Measures.

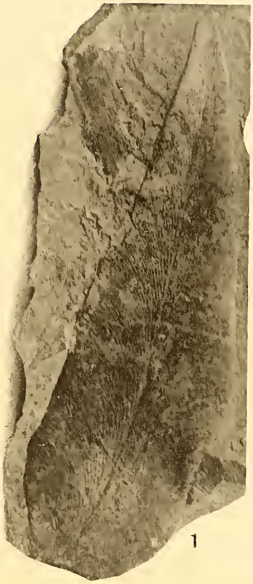
Specimens collected by the Author.

(These photographs need to be examined with a hand-lens.)

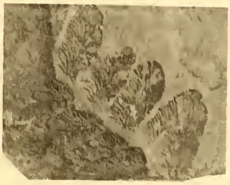
Fig. 1. *Zeilleria delicatula* (Sternb.).
2. Do. do. ×4.
3. { a. *Sphenopteris furcata*, Brongt.
   { b. *Sphenopteris obtusiloba*, Brongt.
4. *Mariopteris* sp.
5. *Lepidodendron lycopodioides*, Sternb.
6. *Lepidodendron Wortheni*, Lesq.



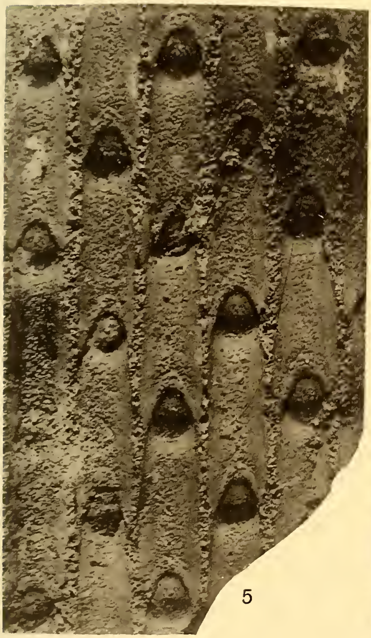
3



1

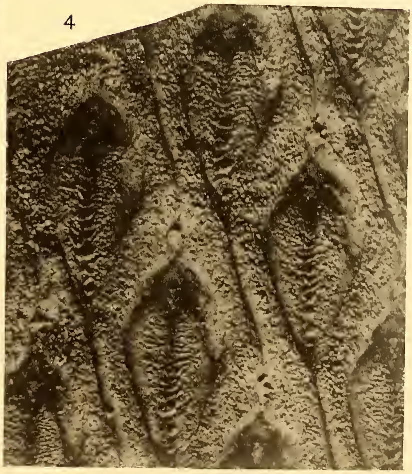


2



5

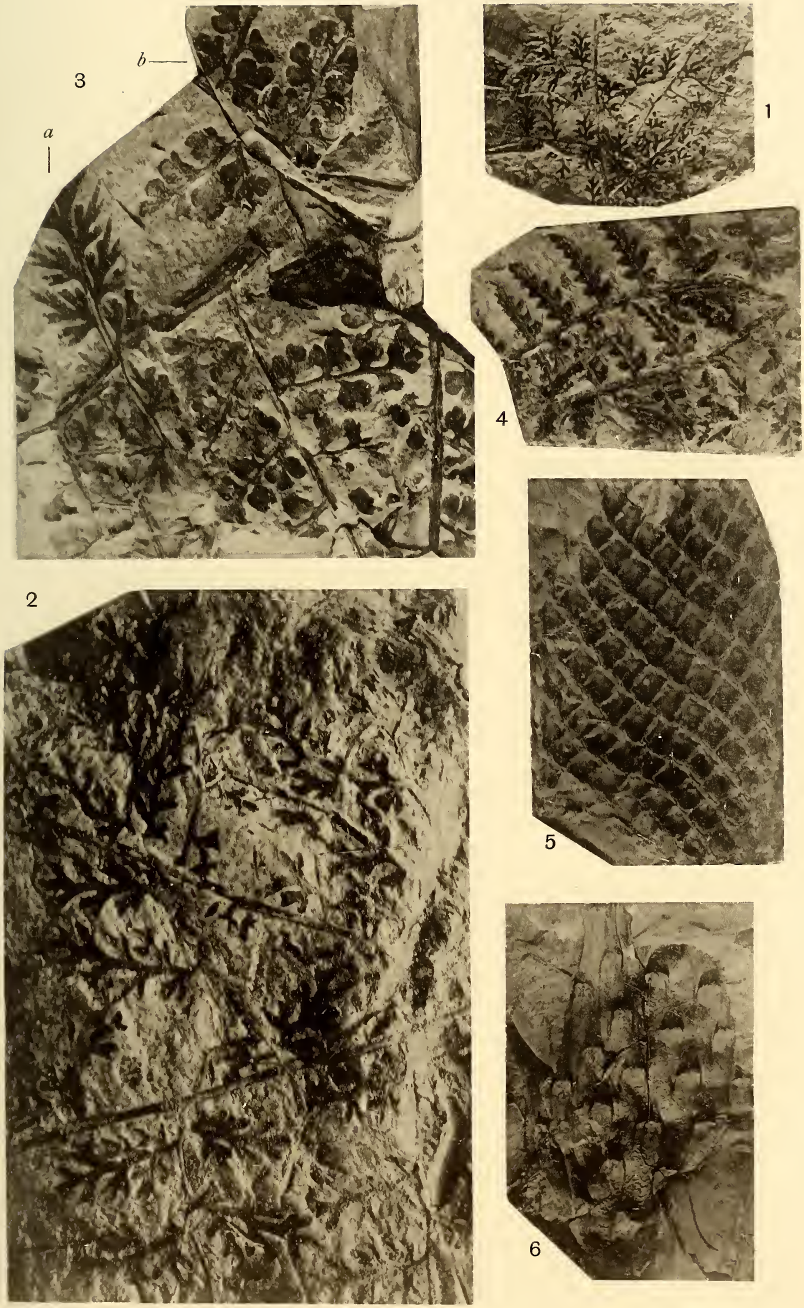
4



Tams, Photo.

Bemrose Ltd., Collo.

Fossil Plants from the Cumberland Coalfield.



Tams, Photo.

Bemrose Ltd., Collo.

FOSSIL PLANTS FROM THE CUMBERLAND COALFIELD.

DISCUSSION.

The PRESIDENT pointed out that, although the Carboniferous was the thickest system in Britain, and had been longest studied, geologists were still very far from having arrived at any universally applicable means of establishing the detailed chronological parallelism of the members of the sequences developed in the separate Carboniferous areas. From the lithological point of view, the groupings associated with the work and publications of Prof. Hull were perhaps of the best available working value. But from the strictly chronological point of view, the only definite conclusion that appeared yet to be regarded as satisfactorily established was that the Carboniferous as a whole was separable into a Lower and Upper division at the base of the Millstone Grit, a result especially due to the researches of Dr. Traquair among the Carboniferous fishes. Of the possible zonal divisions of the Lower Carboniferous, little or nothing was as yet known. But the endeavour to separate the Upper Carboniferous into chronological divisions by means of their characteristic plants —with which were associated especially the names of Stur on the Continent and Kidston in Britain—had now reached a stage which gave every promise of success. It was pleasant to learn that the Author of the paper found that the Upper Carboniferous plants studied by him in the Whitehaven Coalfield had not only a vertical distribution corresponding to that ascertained elsewhere, but they were of value here also as aids in the stratigraphical correlation of their containing beds. He did not gather from the Author's remarks whether the so-called 'Millstone Grit' of the Whitehaven Coalfield could be definitely accepted as such. He believed that the suggested parallelism of the Whitehaven Sandstone with the Lower Pennant Grit of South Wales was not only novel, but an advance of interest and importance.

The SECRETARY, by permission of the President, read the following extracts from a letter received from Dr. WHEELTON HIND :—

'I don't at all know what conclusions Mr. Newell Arber may have arrived at as to the age of the Cumberland Coalfield, but just recently I have been examining a series of lamellibranchs, collected by Miss J. Donald, from the All Hallows coal-pit, which is some little way from Aspatria, in the northern part of the Cumberland Coalfield, and I found *Carbonicola acuta*, *C. aquilina*, and *Anthracomya Williamsoni* among them. The latter is important, as regards its position both in South Wales and the North Staffordshire Coalfield, and points to seams low down in the series. The only bed in which it occurs in North Staffordshire is the Hard-Mine coal, which is generally included in the Lower Coal-Measures; but that subdivision is in North Staffordshire a very arbitrary one, and I should prefer to make the division between Middle and Lower, just below this Hard-Mine seam. The division is as unnecessary as it is arbitrary. I have never in any coalfield found *A. Williamsoni* much off the same line, and consider it a good and reliable index of position. The other two lamellibranchs obtained at All Hallows are found at, above, and below the horizon of *A. Williamsoni*.'

Prof. HULL concurred with the President's statement that the paper was of great interest and value. The list of fossil plants produced by the Author clearly established the Upper Carboniferous age of the Whitehaven Sandstone. He questioned, however, very much whether it could be regarded as the representative of the Pennant Grit of South Wales and Somerset, which he regarded as due to a local and abnormal development of siliceous rock near the centre of the Coal-Measures of the South of England and Wales. On the other hand, he thought it not improbable that the Whitehaven Sandstone had its representative in the Upper Red-Sandstone Series of Lanarkshire and the Clyde Basin, which was well developed at Hamilton.

Dr. TRAQUAIR said that he had listened to the paper with very great interest, but regretted that he was not personally acquainted with the district, nor had he seen any fish-remains from the coal-bearing beds in question. With regard to the stratigraphical value of fishes in the Carboniferous system, he stated that the estuarine fish-fauna of the Lower Carboniferous strata was characterized by a different assemblage of forms from that of the Upper, very few species passing the boundary of the base of the Millstone Grit. As regards the Upper Carboniferous division, almost all the species common in the Lower Coal-Measures reappeared in the Middle, so that the fishes could not be, in the present state of our knowledge, depended on for differentiation between these two horizons. He had seen no fish-remains from the true Upper Coal-Measures of England.

Dr. D. H. SCOTT congratulated the Author on his paper, and on the beauty of his photographs of the fossil plants described. He thought that on palæobotanical evidence the Author had made out a strong case for a Middle Coal-Measure horizon.

The AUTHOR, in reply to the President, said that he did not mean in any way to suggest that the Millstone Grit was absent from the Cumberland Coalfield. Such rocks are marked on the Geological Survey Map (101 S.W.), a few miles inland from the coast, extending from the neighbourhood of Whitehaven to Workington. His observations were intended to call attention to the fact that the Millstone Grit had never been identified in any boring below any of the great coal-seams of the district, and consequently the vertical extent of the Productive Measures was still uncertain.

In reply to Prof. Hull, the Author said that the upper division of the Sandstone Series was doubtless not the exact equivalent of the Lower Pennant Grit of South Wales. The somewhat scanty evidence, at present available, merely suggested that the Upper Sandstone Series may eventually prove to occupy about the same horizon in the Coal-Measures.

The communication forwarded by Dr. Wheelton Hind with regard to the discovery of lamellibranchs by Miss Donald at All Hallows, referred to the Aspatria district of the Cumberland Coalfield, where the age and succession of the beds were also in dispute, and this discovery would probably throw some light on these questions.